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1. Title of the Invention:

Method for Evaluating Alveolar Bone Atrophy

2. Claim:

(1) A method for evaluating the degree of alveolar bone atrophy, comprising: measuring a shading density of an X-ray image of an alveolar bone to prepare a density pattern of the alveolar bone; then, determining, from said density pattern, at least one of indexes including an alveolar bone width (d), an absorption area (ΣGS) and a maximum absorption (GSmax); and evaluating the alveolar bone atrophy from the thus determined indexes.

(2) An aluminum reference substance for use in determining density of an X-ray image of an alveolar bone in an alveolar bone atrophy evaluating method.

(3)The aluminum reference substance according to Claim 2 comprising an aluminum staircase having a maximum height of 15 mm or larger, and a length of from 20 mm to 25 mm.

3. Detailed Description of the Invention

[Industrial Field]

The present invention relates to an alveolar bone atrophy evaluating method. More particularly, the present invention is an application of the MD method known as a method of evaluating, for example, metacarpal bone atrophy, to an evaluating method for an alveolar bone. According to the invention, an optical density of an X-ray image of an alveolar bone is measured to prepare a density pattern for the alveolar bone. From the density pattern, indexes such as an alveolar bone width (d) and an absorption area (ΣGS), are determined, and the thus determined indexes are used to evaluating the degree of the alveolar bone atrophy. The invention also relates to an aluminum reference substance

for use in such evaluating method. The present method enables objective and quantitative evaluation of advancement of periodontal disease, e.g. alveolar pyorrhea.

[Prior Art]

There are various methods for evaluating the degree of atrophy of alveolar bone of patients of periodontal diseases. For example, according to one method, X-ray images are taken and observed with eyes changes in bone shading density, changes in trabecular bone, changes in bone shape, etc. to make comprehensive evaluation. According to this method, difference in evaluation between individuals making evaluation is inevitable, and, therefore, an objective and quantitative method for evaluating bone atrophy is desired.

In orthopedics, the microdensitometry (MD) is known as a method for judging the degree of bone atrophy. For example, the known methods include a metacarpal bone atrophy evaluating method in the orthopedics (T. IOUE et al., Bone Metabolism, 13: 187, 1980), and a radius bone atrophy evaluating method in pediatric (T. SUZUKA et al.: Magazine of Japan Society of Neonatal Medicine; 20 (No.3); 390, 1984.

In the metacarpal bone atrophy evaluating method, as the indexes for use in evaluating the degree of bone atrophy, a cortical bone ratio (the radial and ulnar cortical bone width, d_1+d_2 divided by the bone width D), the bone marrow width d, the maximum bone mineral density GSmax (the average of the radial and ulnar peak heights GS_1 and GS_2 converted to the number of steps of aluminum staircase), the minimum bone mineral density Gsmin, the average bone mineral density $\Sigma GS/D$ (the densitometry area converted to the number of the aluminum staircase and integrated, ΣGS divided by the bone width D), and the bone pattern, are used. In the infant ulnar bone atrophy evaluation, the bone width D and the bone length L are additional used as the indexes. However, the densitometry of teeth and alveolar bone is quite different from the metacarpal or ulnar bone densitometry, and, therefore, the indexes used in the metacarpal or ulnar bone densitometry cannot used for the tooth and alveolar bone densitometry as they are.

[Problem to be Solved by the Invention]

The inventor has considered using the MD method to evaluation of alveolar bones, and studied hard aluminum staircases suitable for evaluation of the

degree of alveolar bone atrophy as well as the indexes used therefor. He has made an aluminum staircase having height and size suitable for X-raying teeth and alveolar bone, and, also found three indexes suitable for evaluation of alveolar bone atrophy, namely, the alveolar bone width, the absorption area, and the maximum absorption.

[Means to Solve the Problems]

The present invention is to provide a method for evaluating the degree of alveolar bone atrophy by measuring the optical density of an X-ray image of an alveolar bone to prepare an alveolar bone density pattern, determining, from the density pattern, at least one of indexes including an alveolar bone width (d), an absorption area (ΣGS) and a maximum absorption (GSmax), and evaluating the degree of alveolar bone atrophy.

According to the invention, first, in order to obtain an X-ray image of an alveolar bone, an upper or lower jaw about a central incisor may be X-rayed with an aluminum staircase inserted as a reference substance. The aluminum staircase must be inserted in such a manner that it does not overlap the teeth between the upper and lower teeth as shown in FIGURE 1. The X-raying can be done under ordinary conditions. It is preferable to take an X-ray image of a central incisor and parts around it since such X-raying is easy and accurate, but an X-ray image of other teeth, e.g. a canine and a molar. When X-raying, an aluminum staircase like the one shown in FIGURE 3 is inserted. Since the optical density range of the X-rayed image of the teeth must be within that of the X-ray image of the aluminum staircase, the height of the aluminum staircase is particularly critical. For that purpose, the maximum height of the aluminum staircase is not smaller than 15 mm, preferably not smaller than 20 mm, and particularly preferably 25 mm. The maximum height is equally divided into, for example, five to provide the height of one step. The length of the aluminum staircase must be such that it can be wholly taken on a dentist's X-ray film, and, therefore, it is suitably from 20 mm to 25 mm. Suitably, the width is from 5 mm to 7 mm. Instead of aluminum staircase, an aluminum slope can be used as well. By the use of this aluminum staircase as the reference substance and determining the absorption area ΣGS converted to the number of staircase steps and the maximum absorption GSmax in the manner as described later, the consistent results can be obtained even when conditions under which X-ray

pictures are taken. It should be noted, however, that if X-raying conditions are too much varied, it is hard to obtain the same results even when the aluminum staircase is used, and, therefore, it is, as a matter of course, desirable to X-ray under conditions as same as possible.

The optical density of the X-ray image of an alveolar bone is usually measured with a densitometer. The part to be measured of the X-ray image is a part at and around the location from one-fifth to a half, preferably one-third of the entire length of the central incisor from the apex. (See FIGURE 1.) In the part too near the crown, the alveolar bone, in particular that of a patient of periodontal disease, is absorbed, and, therefore, it cannot provide a proper measurement. On the other hand, if the measurement is done with respect to a part too near the apex of, particularly, a patient having irregular teeth, there is a possibility that proper measurement for the teeth and the alveolar bone to be measured may not be performed. Once the part to be measured is decided, the same part is measured thereafter. The intensity pattern of an alveolar bone obtainable with a densitometer is magnified by from five to ten before storing in a chart because a stored, magnified chart can provide accurate measurements of the alveolar bone width etc. mentioned later. The densitometry of the aluminum staircase inserted as the reference substance is recorded in the chart in the form of the measurement of substantially the center of the staircase after being magnified by, for example, two.

FIGURE 2 shows an example of a densitometry (density pattern) of an alveolar bone and aluminum staircase. In this chart, parts having a low optical density (white in the X-ray image) are recorded in the lower part of the chart, and parts having a higher optical density (dark in the X-ray image) are recorded in the upper part of the chart. Thus, the chart shows that the alveolar bone portions shaded with respect to the incisors are seriously damaged. Since, as the part where the bone resorption is larger, the part on the X-ray image is darker, and its optical density is higher, so that the pattern extends further upward in the chart.

Then, the following three indexes have been set, deeming that, as shown in FIGURE 2, the shaded parts above the tangent at the lowermost edge of the densitometry between adjacent teeth are the densitometry of the alveolar bone portion.

(1) Alveolar Bone Width: d

In the density pattern, a perpendicular line is dropped from the maximum optical density point, and the width of the shaded portion at a midpoint on the perpendicular line between the maximum optical density point and the tangent to the adjacent teeth, i.e. the half-width, is determined as the alveolar bone width d. The measurement can be made using ordinary means, such as a scale or a vernier micrometer. Generally, the value d becomes larger as the periodontal disease is more serious.

(2) Absorption Area: ΣGS

The absorption area is the area of the shaded portion of FIGURE 2 converted to the height of the aluminum staircase and integrated, which is preferably be calculated by means of a computer. As the periodontal disease is more serious, the absorption area is larger and the difference from the healthy becomes particularly more significant as will be discussed in the later mentioned Example 3. Therefore this index is the most useful index.

(3) Maximum Absorption: GSmax

The maximum absorption GSmax is the difference between the maximum optical density converted to the step number of the aluminum staircase and the density at the intersection of the perpendicular line from the maximum optical density point and the tangent to the adjacent teeth converted to the step number of the aluminum staircase. The value of GSmax is larger as the periodontal disease is more serious and, therefore, is important second to ΣGS.

These three indexes can be individually used as an index in evaluating the degree of alveolar bone atrophy of a periodontal disease patient, or two or more can be used in combination for comprehensive estimation. For example, a larger absorption area ΣGS can be evaluated as indicating that the periodontal disease has been advancing, and, when it is combined with the alveolar bone width (d) and the maximum absorption (GSmax), more objective and quantitative evaluation of the advancement of the periodontal disease can be made.

[Effect of the Invention]

As described above, by the use of the indexes derived from the density pattern of an alveolar bone, namely, the alveolar bone width (d), the absorption

area (ΣGS) and the maximum absorption (GSmax), the current state of the degree of atrophy of the alveolar bone of a periodontal disease, e.g. pyorrhea alveolaris, can be objectively and quantitatively grasped. Furthermore, measuring at time intervals can give measures to see the effects of treatments.

[Examples]

The invention is described in detail by means of examples.

Example 1

An upper or lower central incisor portion was X-rayed according to the standard by a dentist's X-ray apparatus, with an exposition time period of 0.51 seconds, with various aluminum staircases shown in TABLE 1. A microdensitometer (Model NCS available from Joyce Loebl) was used to measure a part at 1/3 of the length of the entire central incisor from the apex. The resulting density pattern was magnified by five before storage, and, at the same time, the density of the aluminum staircases were measured. The alveolar bone width d, and the absorption area ΣGS and maximum absorption GSmax converted to the number of steps of the aluminum staircases, were determined from the resulting chart. The optical density range of the teeth did not fall within the optical density range of the aluminum staircases Nos. 1-3, and, therefore, the indexes ΣGS and GSmax relating to the bone mineral density could not be obtained.

TABLE 1

No.	Size of Aluminum Staircase (mm)						Measurements		
	Step Height	Number of Steps	Width	Total Length	Minimum Height	Maximum Height	d	ΣGS	GSmax
1	0.5	5	7	25	0.5	2.5	1.65	unmeasurable	
2	1	7	7	25	1	7	1.80	unmeasurable	
3	2	5	7	25	2	10	1.83	unmeasurable	
4	3	5	7	25	6	10	3.60	4.95	1.38
5	5	5	7	25	5	25	3.60	4.02	1.27

Example 2

A part about the lower central incisor of a fifty-year-old man was X-rayed

three times under the same conditions, with an aluminum staircase of five steps each having 5 mm high inserted, to thereby obtain three X-ray images.

One of the three X-ray pictures was measured with the microdensitometer three times in the same manner as Example 1, for the densities of the part at 1/3 from the apex and the aluminum staircase, and the measurements were recorded in a chart.

For one of the three densitometries, the alveolar bone width d was measured three times be means of a vernier micrometer, and the absorption area ΣGS and maximum absorption GSmax converted to the number of the steps of the aluminum staircase were measured three times by means of a computer. The other X-ray images were subjected to measurement by the microdensitometer once, and, for each densitometry, d and ΣGS and GSmax were measured once by means of a vernier micrometer and a computer, respectively. From the measurement results, the measurement error associated with the vernier micrometer and the computer, the measurement error associated with the microdensitometer, and the measurement error associated with the X-raying were calculated as variation factors $CV = \sigma/\bar{x} \times 100\%$, which are shown in TABLE 2. All of the errors were smaller than 10 %, which indicates that the present method is practically useable.

TABLE 2

Error \ Index	Alveolar Bone Width d	Absorption Area ΣGS	Max. Absorption GSmax
Computer and Vernier Micrometer Measurements	0	4.39	2.45
Densitometer Measurement	0.78	5.30	2.55
X-Raying	2.18	6.80	1.92

Example 3

Upper or lower central incisor portions of healthy persons and patients of periodontal disease at different seriousness levels were X-rayed in a manner similar to Example 2. The measurements of the alveolar bone width d, the

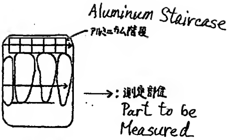
absorption area ΣGS and the maximum absorption GSmax of each person are shown in TABLE 3. As the periodontal disease becomes serious, the values of the respective indexes increase, showing that the respective indexes employed in the method of the present invention are useable in evaluating the seriousness of the alveolar bone atrophy of patients of periodontal disease. In TABLE 3, "L2-L1" denotes the measurement of a part between the second and first incisors on the left side, "L1-R1" denotes the measurement obtained from the part between the left first incisor and the right first incisor, "R1-R2" denotes the measurement obtained from the part between the right first and second incisors.

TABLE 3

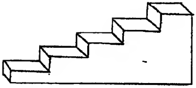
No.	Condition	Sex	Age	L2-L1			L1-R1			R1-R2		
				d	ΣGS	GSmax	d	ΣGS	GSmax	d	ΣGS	GSmax
1	Healthy	Male	30	3.17	0.17	0.51	3.13	0.17	0.39	3.40	0.34	0.39
2	Healthy	Female	28	3.2	0.18	0.59	2.5	0.14	0.45	3.3	0.30	0.37
3	Slight	Male	55	8.43	0.67	0.61	12.60	0.80	0.57	5.33	0.30	0.51
4	Slight	Female	60	8.17	0.72	0.81	10.47	0.48	0.54	7.57	0.44	0.58
5	Slight	Male	63	7.50	0.57	0.74	13.60	0.98	0.66	8.17	0.53	0.61
6	Middle	Male	56	5.03	0.88	1.05	16.90	1.39	0.67	3.50	0.41	0.68
7	Middle	Male	58	4.9	0.67	0.93	11.9	1.55	0.92	6.1	0.51	0.65
8	Middle	Female	49	7.77	0.80	1.02	13.03	1.50	0.96	22.2	1.42	0.84
9	Serious	Male	70	9.7	0.44	0.55	19.6	1.94	1.03	10.07	0.41	0.48
10	Serious	Female	61	14.2	0.93	0.67	21.0	2.12	0.95	7.1	0.46	0.63
11	Serious	Female	62	11.3	1.03	0.91	18.3	2.05	1.14	11.1	0.50	0.41

4. Brief Description of the Drawings:

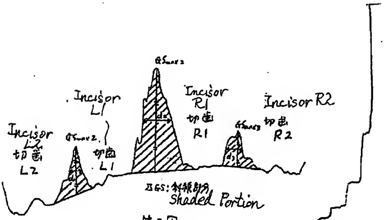
FIGURE 1 schematically shows an aluminum staircase and teeth when their X-ray image is being taken; FIGURE 2 shows a density pattern of an alveolar bone and a density of an aluminum staircase; and FIGURE 3 shows an example of aluminum staircase.



第1図
FIG.1



第3図
FIG.3



第2図
FIG.2